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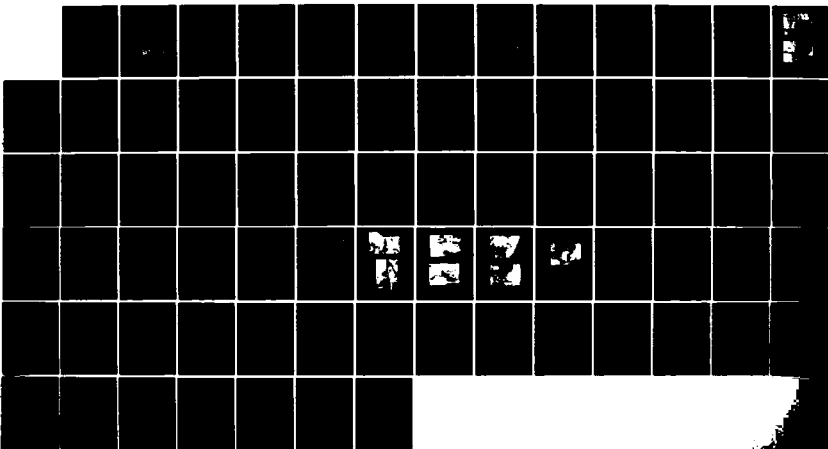
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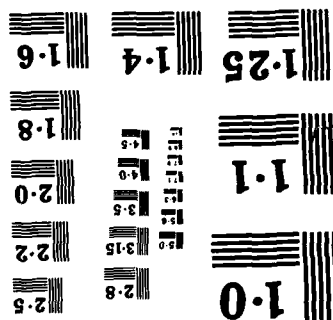
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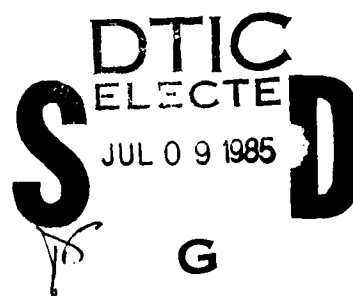
MERRIMACK RIVER BASIN
BRADFORD, NEW HAMPSHIRE

TODD LAKE DAM

NH 00288

NHWRB 28.01

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1978

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

Honorable Meldrim Thomson, Jr.
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

DEC 11 1973

Dear Governor Thomson:


I am forwarding to you a copy of the Todd Lake Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, The Lake Todd Association, P.O. Box 168, Bradford, New Hampshire 03221.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,


JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

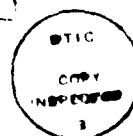
TODD LAKE DAM

NH 00288

MERRIMACK RIVER BASIN
BRADFORD, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Merrimack River Basin. Bradford New Hampshire Ring Brook		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is a concrete capped, gravity rock wall and earth fill structure with a maximum height above the downstream channel of 16.5 ft. The dam's size is intermediate with a significant hazard potential. The dam is in fair condition. Deficiencies in the areas of spillway capacity and possible structural stability require additional engineering investigations. Only a few relatively minor operation and maintenance improvements are necessary.		

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.: NH 00339
NHWRB No.: 166.04
Name of Dam: TODD LAKE DAM
Town: Bradford
County and State: Merrimack, New Hampshire
Stream: Ring Brook
Date of Inspection: 1 June 1978, 8 July 1978 (Measurements),
12 July 1978 (Hydrology)

BRIEF ASSESSMENT

Todd Lake Dam is a concrete capped, gravity rock wall and earth fill structure with a maximum height above the downstream channel of 16.5 feet. The 57 foot long concrete cap serves as a spillway and includes two 12 foot long depressed sections which permit the installation of 12 inch high flashboards. The left abutment includes the outlet works which consist of two inlets and an outlet into 5.8 foot diameter wooden penstock; the outlet works are completely sealed, however. Initial construction was in 1858 with subsequent alterations in 1886 and 1946. No original plans are available.

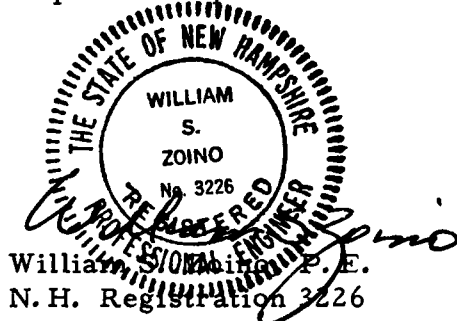
The dam discharges into Ring Brook which joins the West Branch of the Warner River just below the dam. The drainage area consists of heavy, moderately sloping forest. The dam's normal impoundment of 1100 acre-feet places it in the INTERMEDIATE size category. The hazard potential classification of SIGNIFICANT results from the extensive property damage, but unlikely loss of life, expected downstream in the event of the Spillway Test Flood (STF).

The dam is in FAIR condition at the present time. Deficiencies in the areas of spillway capacity and possible structural stability require additional engineering investigations. Only a few relatively minor operation and maintenance improvements are necessary.

Based on size and hazard classification in accordance with the Corp's guidelines the Spillway Test Flood (STF) is in the range of the Probable Maximum Flood (PMF) and the 1/2 PMF. An inflow STF of 14,000 cfs (760 csm) yields a maximum outflow at the dam of 11,500 cfs (620 csm). This flow, 11,500 cfs, would result in overtopping of the dam by 6.8 feet. The maximum flow over the dam that will not result in overtopping is 1350 cfs. Thus, the spillway is considered inadequate and a major storm could result in dam failure. The resolution of this problem requires a considerable increase in the discharge capacity of the dam or the provision of suitable emergency spillway facilities. Because significant extension of the existing dam does not appear feasible and because the road bridge immediately downstream creates a flow restriction during major floods, the eventual solution may involve some modifications to both structures.

Operationally, the dam requires repair of the right downstream training wall, cleaning and sealing of some cracks and repair of some spalls in the concrete portions of the structure and clearing of the downstream channel. The installation of a gauge near the dam would assist the owners in better monitoring discharges during flood periods.

The above recommendations and remedial measures should be implemented by the owner within one to two years after receipt of the Phase I Inspection Report.



William S. Zoino, P. E.
N. H. Registration 3226



Robert Minutoli, P. E.
Mass. Registration 29165

This Phase I Inspection Report on Todd Lake Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.



CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

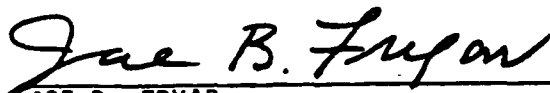


FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division



SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:



JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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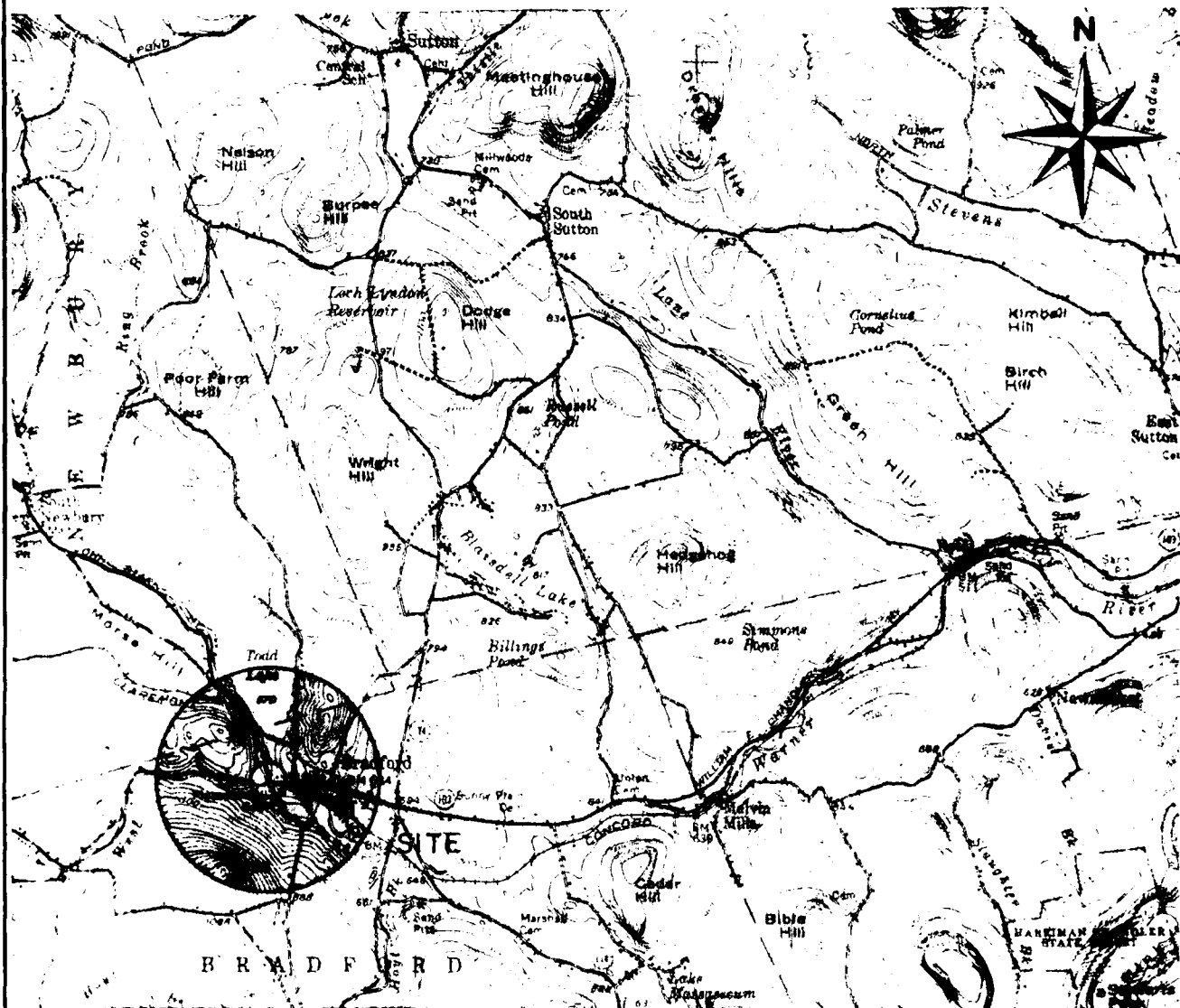
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Overview from left side downstream (8 July 78)



Overview from downstream channel (8 July 78)



SCALE -
0 1/2 2 miles
FROM JSGS MT. KEARSARGE, N.H.
QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

LOCUS PLAN

TODD LAKE DAM

NEW HAMPSHIRE

FILE No. 2067

SCALE AS NOTED
DATE JULY 1978

PHASE I INSPECTION REPORT

TODD LAKE DAM

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunncliff & Associates, Inc. (G.Z.D.A.), has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to G.Z.D.A. under a letter of May 3, 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW 33-78-C-0303 has been assigned by the Corps of Engineers for this work.

(b) Purpose

- (1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.
- (2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.
- (3) Update, verify and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-Federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The dam lies at the south end of Todd Lake near the intersection of old Route 103 and Morse Hill Road in the town of Bradford, NH. The portion of the USGS Mt. Kearsarge, NH quadrangle presented previously shows this locus. Figure 1 of Appendix B presents a detail of the site developed from the map and the site inspection.

(b) Description of Dam and Appurtenances

The dam consists essentially of a gravity rock wall and earth fill structure with a base width estimated at 20 feet and a maximum height of 16.5 ft. (Figure 2). A concrete spillway covers the gravity structure over its entire 57 foot length and has two 12 foot long depressed sections, one near each end, which permit the installation of 12 inch flashboards (Figure 2). The left abutment incorporates the dam's outlet works which consist of a concrete box with two inlets and one outlet. Stop-logs at one time regulated flow through the outlet which then led into a now boarded up 5.8 foot diameter wooden penstock (Figure 3). The previous owner has sealed both inlets, probably by boarding, one of which is on the right side. No special hazard is believed to attend the penstock. The outlet works originally provided flow for the operation of a saw mill complex, only part of which remains today, having been converted into a one family home. Old concrete footings for the mill buildings still exist around the dam. The wooden penstock runs into the converted mill building, as does the small amount of water which leaks through the boarded up outlet works. A concrete lined channel carries this flow under the house. A concrete arch bridge permits flow under old Route 103 approximately 100 feet downstream of the dam.

(c) Size Classification

The dam's normal impoundment of 1100 acre-feet places it in the INTERMEDIATE size category as defined in the "Recommended" Guidelines."

(d) Hazard Potential Classification

Only the converted mill building and 2 other houses lie in the downstream hazard area for a failure of this dam. While damage to these structures and to the road bridge immediately downstream of the dam would be significant there is little potential for loss of life. For these reasons, the hazard potential is considered SIGNIFICANT.

(e) Ownership

All lakeshore residents have a part ownership in the dam included in their property deeds as of 1968. The Lake Todd Association, a voluntary organization of the littoral property owners, controls the dam through its dam committee. Mr. Donald A. Garman, P.O. Box 168, Bradford, NH 03221 is the association's president. His phone number is 603-938-2314. From 1954 to 1968, Mr. Edwin Westerborg, RFD 1, Bradford, NH 03221 (603-938-2296) owned the dam.

(f) Operator

The only functional features of the dam at present are the two 12 inch flashboards. Mr. Garman, the Association president, controls their installation and removal.

(g) Purpose of Dam

While formerly used to store water for industrial use in the mill, the dam's only purpose at present is to maintain the lake level for summer recreational use.

(h) Design and Construction History

A 1934 New Hampshire Water Resource Board (NHWRB) report indicates that original construction was in 1858 with a reconstruction in 1886. Mr. Westerborg indicates that in 1946, the mill operator and dam owner Mr. Milner altered the dam to its present configuration by constructing the concrete spillway and repairing the wooden penstock. Mr. Milner drained the lake prior to construction and Mr. Westerborg reports that the rock and earth fill portion of the dam was approximately 20 feet wide at the base. No plans for the dam are available.

(i) Normal Operational Procedure

The Lake Todd Association installs the flashboards by Memorial Day at the latest and removes them by the end of September.

1.3 Pertinent Data

(a) Drainage Area

Todd Lake receives runoff from a 18.5 square mile drainage area. The majority of this area is heavily forested with moderately steep slopes toward the lake. Several small streams including Ring Brook and an unnamed stream from Loch Lyndon Reservoir discharge into Todd Lake. A large part of the development around the lake is permanent and year-round in nature

(b) Discharge at Dam Site

No formal record of historic peak floods is available for Todd Lake. There is a nearby downstream USGS gauge (01085800) on the West Branch of the Warner River, however, which provides local runoff records since 1962. For the period 1962-1978, the peak runoff is 555 cfs from a 5.75 square mile drainage area. If transposed to the Todd Lake drainage basin, this same runoff would yield an approximate peak flow of 1790 cfs.

Mr. Westerburg indicated that the maximum flood during his 50 year residency in the area occurred during the hurricane of 1938. He reports that water flowed 5 to 6 feet over the dam and that only the backwater created by the nearby roadbridge counteracted the pressures created by the tremendous flow and prevented the dam from being washed out. The 1938 flows are estimated to be in the range of 1600 to 2500 cfs.

(c) Elevation (ft. above MSL assuming Lake Todd at 670'± per 1956 USGS)

- (1) Top dam: 673.5
- (2) Recreation pool: 670 ± (with flashboards)
- (3) Spillway crest: 669±
- (4) Streambed at centerline of dam: 656±

(d) Reservoir

- (1) Length of maximum pool : 6800 ft.
- (2) Storage - recreational pool: 1100 acre-feet @ 670 MSL
- top of dam: 1513 acre-feet @ 673.5 MSL
- (3) Reservoir surface: 168 acres @ 670 MSL

(e) Dam

- (1) Type: Gravity rock wall and earth fill with concrete spillway
- (2) Length: 57 ft.
- (3) Height: 16.5 ft.
- (4) Top Width: 10 ft. \pm
- (5) Side Slopes: Downstream vertical, upstream 1:1
- (6) Zoning, impervious core, cutoff, grout curtain: Unknown

(f) Spillway

- (1) Type: Concrete weir with 2 flashboard sections
- (2) Length of weir: 33 ft. (excluding flashboard sections)
- (3) Crest elevation: 669 ft. \pm
- (4) Gates: 2 flashboard sections, each 12 ft. long
- (5) Upstream Channel: Shallow approach from pond
- (6) Downstream Channel: Narrow channel with steep sides and rocky bottom

(g) Regulating Outlets

The only regulating outlets presently in use are the two flashboard sections which permit the installation and removal of 12 inch high flashboards. The base of the flashboards is at elevation 669 ft. \pm .

Previous owners boarded up the dam's main outlet works described in Section 1.2(b). The inlet on the upstream side of the inlet is 4 ft. by 4 ft. It was impossible to determine the dimensions of the inlet on the right side. The top of the stoplogs at the outlet to the wooden penstock are 5.3 ft. below the top of the concrete box structure.

SECTION 2 - ENGINEERING DATA

2.1 Design

The design of the present structure is quite simple and appears adequate in all respects except ability to pass the Spillway Test Flood (STF). At the time of its design, however, engineers rarely considered floods of the magnitude now under study. Plans for neither the original nor rebuilt structure are available.

2.2 Construction

Visual inspection of the dam detected no significant construction deficiencies in the structure. Of key concern is the lack of accurate data as to the size of the gravity structure and of any information regarding the internal makeup of the dam. In general, the quality of construction is probably as good as can be expected for a structure of this type built during this period.

2.3 Operation

The facts that very little leeway in operation exists and that the residents themselves control the dam result in generally satisfactory operation.

2.4 Evaluation

(a) Availability

As mentioned above, the original plans are not available, if indeed they still exist. Previous inventory reports, sketches and correspondence concerning the dam, supplemented by the observations of the inspection team and discussions with knowledgeable residents, form the basis of the information presented herein.

(b) Adequacy

The lack of indepth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but its evaluation is based primarily on visual inspection, past performance history and engineering judgment.

(c) Validity

The direct examination and performance history form a valid basis for evaluation.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

The Todd Lake Dam is in FAIR condition at the present time and requires no immediate remedial measures for continued safe operation.

(b) Dam

(1) Spillway (Photos 1 and 2)

The spillway is 57 feet long with a crest width of approximately 10 feet. The surface of the spillway consists of a concrete cap placed on the dry stone masonry dam. The cap is approximately 12 inches thick. With the exception of a horizontal crack stretching 24 ft. from one flash-board section to the other, there is no evidence of spalling or other deficiencies in the crest. The flashboards are in good condition.

The downstream face of the dam consists of dry squared stone masonry and rubble stone masonry. The dry squared stone masonry is adjacent to the right abutment and extends along the spillway face for approximately 10 feet. Some stones are dislodged out of alignment (Photo 1). Rubble stone masonry at approximately mid-length of the spillway has bulged outward and some has unraveled out of place and fallen into the channel bed. A 1939 inspection by the NHWRB noted this same deficiency. The bulge is approximately 6 feet in height and voids due to dislodged stones are 2 to 3 feet above the channel bed (Photo 2). No leaks through the stonework were evident.

(2) Abutments (Photo 4)

The abutments consist of dry stone masonry capped with concrete. The dry squared stone masonry forming the right abutment is no longer plumb with evidence of numerous displaced stone. There is a void approximately 6 inches by 2 feet long between the dry stone and the concrete cap. The concrete cap on the right abutment contains medium random cracks and efflorescence. The left abutment joins a concrete pier located at the edge of the spillway. This pier rests in the channel bed. Dry stone masonry

supports the balance of the abutment. This abutment has spalled with evidence of medium random cracks and efflorescence (Photo 4). Heavy boulders sloping from the channel bed to the bottom of the concrete cap preclude visual inspection of this abutment. The concrete cap on the left abutment is in fair condition. No leaks through or around the abutments were evident.

(c) Appurtenant Structures (Photos 3 and 6)

The left abutment, as shown in Photo 3, is of concrete, and overtopping flows would deflect into an open area to the east of the converted mill. A concrete outlet is integral to the left abutment and internal dimensions are approximately 7 feet wide and 11 feet long. The structure is approximately 9 feet deep. The concrete contains medium random cracking and efflorescence. The water level within the structure was approximately 1 foot below lake level on June 1, 1978. The structure has two inlets and one outlet. One inlet is on the upstream face of the structure and the other is in the right wall. The upstream inlet consists of a 4 foot by 4 foot opening. It was not possible to measure the dimensions of the right inlet. Both inlets are sealed with wood. The outlet, which has stop-logs set in place, is on the downstream end of the structure. The top of the stop-logs are 5.3 feet below the top of the structure. Due to their submerged condition, visual inspection of the stop-logs is not possible, however a representative of the owners indicated that they are 4 inches in nominal thickness. There is leakage at the inlet end of the penstock, probably due to faulty seating of the stop-logs. The wood stave penstock is in poor condition and beyond salvage. At least 50 percent of the staves are completely deteriorated (Photo 6).

(d) Reservoir

An inspection of the reservoir shore revealed no evidence of movement or other instability. No sedimentation was evident behind the spillway. Examination of the surrounding area revealed no work in progress or recently completed which might increase the flow of sediment into the lake. Additionally, there were no changes to the surrounding watershed which might adversely affect the run-off characteristics of the basin.

The relocation of Route 103 across the old railroad embankment has no effect on the lake level. The bridge constructed near the east end of the embankment is sufficiently large to allow the two bodies of water to act as one.

There is considerable development, both seasonal and year-round, on the Todd Lake shoreline. Many houses are less than 10 feet above normal lake level. If major flooding occurred, many structures would likely suffer significant damage.

(e) Downstream Channel (Photo 5)

There are no downstream conditions which adversely affect the operation of the dam or which pose a hazard to the safety of the structure.

The existence of the road bridge just downstream of the dam would create significant backwaters at the dam in the event of the STF, a situation more beneficial than harmful in terms of the dam's structural stability. The bridge is a concrete arch with a width of approximately 16 feet and a maximum height of approximately 16.5 feet. The narrow, steep channel for some distance downstream virtually assures high water levels around the channel, but the lack of any significant downstream development indicates that property damage is the greatest danger.

The collapsed downstream training wall on the right side (Photo 6) presents no immediate hazard to the dam or to downstream areas, but does require routine repair to channel discharge properly and to prevent undermining of the nearby road.

3.2 Evaluation

Because the dam is of simple design and because most of its major components are accessible for examination, the visual inspection permitted an overall satisfactory evaluation of those items which affect the safety of the structure, and the overall condition of the dam and appurtenant works is considered as FAIR.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Each year, the Lake Todd Association installs the two 12-inch flashboards before Memorial Day and removes them in late September. The dam presently has no other operation features and the association has had no reason or received any complaints which would cause them to alter this procedure.

4.2 Maintenance of Dam

The present owners have performed no significant maintenance on the dam since assuming control. The extensive alteration performed in 1946 appears to be the last major maintenance effort on the structure.

4.3 Maintenance of Operating Facilities

The dam's flashboards require only minimal attention.

4.4 Description of Any Warning System in Effect

No formal warning system exists for the dam. For this particular structure the lack of any real operational capacity at present indicates that a warning system is only effective for notification of impending failure. In all probability, the interest of local residents would adequately serve this purpose.

4.5 Evaluation

The established operational procedures are adequate for Todd Lake Dam given its limited operational capacity.

SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 Evaluation of Features

(a) Design Data

The data sources available for Todd Lake Dam include the "Inventory of Dams and Water Power Developments" by the New Hampshire Water Resource Board, dated October 10, 1934, and "Data on Dams in New Hampshire" by the New Hampshire Water Control Commission, dated October 26, 1938, and updated July 15, 1942. These sources deal primarily with the characteristics of the dam and its spillway.

A June 26, 1944 application for repair of the dam is also available, as is a series of letters written in 1967 and 1968 dealing with high flows in the West Branch of the Warner River downstream of Lake Todd. More recent data include "Dam Safety Inspection Report Forms" and "Site Evaluation Data" from the New Hampshire Water Resources Board, dated May 17, 1971, August 19, 1975, and April 28, 1976. There is also a series of letters between the New Hampshire Water Resources Board and the Lake Todd Association (owner/operator of the lake) regarding the need for a controlled outlet at the dam. The New Hampshire Water Resources Board wrote on January 27, 1976 requesting "corrective action ... to increase flow capacity during floods." The data also include a May 20, 1977 letter from the Corps of Engineers to the Lake Todd Association explaining that federal funding is not available for this type of corrective action.

(b) Experience Data

No formal record of historic peak floods is available for the Todd Lake Dam. There is a nearby USGS gauge (01085800) on the West Branch of the Warner River that provides runoff records since 1962. For the period of record, the peak runoff is 555 cfs from a drainage area of 5.75 square miles. The same runoff rate, if transposed to the Todd Lake drainage basin, would yield an approximate peak runoff of 1,790 cfs. The recollections of one of the previous owners, discussed in Section 1.3 (b) provide additional insight into the discharges possible in this area, in this case on the order of 1600-2500 cfs after the 1938 hurricane.

(c) Overtopping Potential

This Phase I investigation focuses on the adequacy of the dam in terms of its overtopping potential and its ability to allow an appropriately large storm to pass safely. This approach requires investigations to determine how the recommended Spillway Test Flood (STF) compares with the dam discharge and storage capacities. Since none of the original hydraulic and hydrologic design records are available for use in this study, the analysis requires some of the basic calculations reported herein.

The "Recommended Guidelines" specify Spillway Test Flood criteria based on the size and hazard potential classifications of the dam. As shown in Table 3 of that publication, the appropriate STF for a dam classified as INTERMEDIATE in size with SIGNIFICANT hazard potential, is between 0.5 to 1 times the Probable Maximum Flood (PMF).

The chart of "Maximum Probable Flood Peak Flow Rates" obtained from the Corps of Engineers, New England Division permits an estimate of the PMF. The calculations use "rolling" topography with a drainage area of 18.5 square miles. However, the existence of the Loch Lyndon Reservoir and extensive swamp lands along Ring Brook tend to partially lower the appropriate estimate for the peak runoff rate. This results in a maximum probable runoff rate into the lake of about 1,250 cfs/square mile or 23,125 cfs, one-half of which is 11,565 cfs.

The "Recommended Guidelines" suggest that where a range of possible STF's is indicated, the analysis should consider the magnitude most closely relating to the involved risk. On this basis, since the risk for Todd Lake is most likely at the lower end of the SIGNIFICANT category, an STF closer to one-half the PMF is appropriate. In this case, a value of 14,000 cfs is reasonable for an uncorrected STF inflow. Application of the procedure suggested by the Corps of Engineers (New England Division) for "Estimating the Effect of Surcharge Storage on Maximum Probably Discharges" results in a final STF outflow of about 11,500 cfs.

The Storage-Stage curve used to attenuate the STF results from assuming a lake area of 168 acres and allowing for a simple linear relation for storage versus elevation above spillway crest. Appendix D presents this curve.

The discharge capacity of the Todd Lake Dam depends on the outlet characteristics and on the level of the water surface in the lake. Under most flow conditions the spillways and the top of the dam control discharge from the lake. If the lake level overtops the dam abutments, then the discharge capacity depends on the characteristics of the dam crest and the side walls along the abutments.

The analysis of the dam's discharge during the STF presented in Appendix D uses the following assumptions.

- (1) Blockage of the penstock gate is complete.
- (2) The force created by the flow over the dam washes out the flashboards.
- (3) Once overtopped, the walls on either side of the dam act as sharp crested weirs while the level lot on the east side acts as a broad crested weir. The slopes beyond the wall on the west side and beyond the parking area on the east side assume the characteristics of broad-crested weirs on 1:1 side slopes.

The Discharge-Storage curve in Appendix D illustrates the total outflow from the lake for any given stage. As the calculations indicate, the STF of 11,500 cfs will overtop the dam by 8.5 feet.

5.2 Hydrologic and Hydraulic Evaluation

Given the limited flow capacity of the spillway at Todd Lake Dam, the recommended STF will significantly overtop the dam and its abutments. Furthermore, since the maximum capacity before overtopping is only 1,350 cfs, overtopping will also occur for many storms of smaller magnitude than the recommended Spillway Test Flood.

Route 103 as reconstructed cuts the lake in half where it follows along the former railroad embankment. If the opening through the embankment was small enough to severely restrict flow, the embankment might serve to partially dam the river and attenuate the peak flow entering the lake below the embankment. Examination of the highway bridge however, indicates that the area beneath the bridge equals approximately 750 square feet and that there is relatively little freeboard between the low chord of the bridge and top of the embankment. This combination of the large flow area and probability of overtopping under surcharge suggests that the highway does not clearly define two lakes and thus would not limit the peak flow at the dam for very large floods. The highway opening is thus hydraulically insignificant.

In the event of a flood of the Spillway Test Flood magnitude, three structures immediately downstream of the dam would suffer severe damage. They are the old mill building, since converted to a residence, and the two houses which overhang the stream immediately downstream of the first road bridge. A larger number of lakeside homes upstream of the dam would suffer severe flooding by the stage in the lake that would accompany an STF magnitude flood.

It is unlikely that the Todd Lake Dam would rise to the overtopping level without sufficient time to evacuate the residents of the downstream structures immediately threatened. There is very limited development downstream for a considerable distance and, thus, the need to improve the spillway capacity is more a function of preventing flooding upstream along the shores of the lake than downstream due to dam failure. However, the purposes of the dam safety review do not include the prevention of upstream flooding on the lake shore.

5.3 Downstream Dam Failure Hazard Estimates

Use of the procedures set forth in "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs," Corps of Engineers, New England Division, April 1978, permits estimation of the flood hazards in downstream areas resulting from a failure of the dam. This procedure includes the attenuation of dam failure hydrographs in computing flows and flooding depths for downstream areas. The calculations take into account the hydraulic and storage characteristics of channel reaches downstream of the dam and assume that failure occurs when the lake level rises 4.5 feet over the spillway, or with the initial flow of water over the left abutment.

The evaluation divides the channel downstream of Todd Lake Dam into three reaches. The first reach extends from the dam to the first bridge immediately downstream. The second reach runs along Ring Brook and the Warner River to the covered bridge. The third reach is from this bridge to the Highway 114 bridge across the Warner River.

Cross-sections taken from the USGS quadrangle provided the basis for estimating depths of flooding for each downstream reach. In each case, the flooding would overflow the natural stream banks but would remain in the low areas along the banks. With the exception of those mentioned previously, there are no known structures in the area flooded for the three reaches considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

With the exception of the bulge near the center of the downstream face, the field investigation revealed no significant displacements and/or distress which warrant the preparation of structural stability calculations based on assumed sectional properties and engineering factors. The potential hazard from the bulge is not clear, particularly in light of its existence since at least 1939. Section 7 includes a recommendation with respect to this feature.

(b) Design and Construction Data

As mentioned previously, no plans or calculations of value to a stability assessment are available for this dam.

(c) Operating Records

There are no formal operating records in existence for this dam. However, contact with long-time residents revealed no visual evidence of any instability during past floods. The survival of the dam during the 5 to 6 foot overtopping in 1938 provides some insight into its stability, but this incident may, however, have caused the present bulge, first noted in 1939.

(d) Post Construction Changes

The alteration accomplished in 1946 did not affect the stability of the structure. The results of the field inspection and a check of the available records produced no evidence of other changes to the dam which might influence its stability.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines does not warrant seismic analyses.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Todd Lake Dam is in FAIR condition at the present time.

(b) Adequacy of Information

The known characteristics of the dam, its drainage area and its downstream areas are such that the information now available permits a satisfactory evaluation.

(c) Urgency

The engineering studies and improvements described herein should be implemented by the owner within 1 to 2 years after receipt of the Phase I Inspection Report.

(d) Need for Additional Investigation

Further investigations to determine the influence of the bulge on the stability of the dam and the affects of the old Rte. 103 bridge immediately downstream are necessary.

7.2 Recommendations

(a) As the dam will not pass the test flood without severe overtopping, further structural and hydrologic studies are necessary by competent consulting engineers to determine the effect of overtopping and what measures may be necessary to improve discharge capabilities.

(b) The cause and possible effects of the bulge in the downstream face of the dam are not known. An engineering study of this situation is necessary to insure the long-term safety and stability of the dam.

(c) Possible adverse effects of the apparently constricted opening of the Old Rte. 103 bridge downstream should be inspected.

7.3 Remedial Measures

(a) Alternatives

With the exception of the two areas discussed in the preceeding paragraph, the dam suffers from only minor deficiencies. The long-term safety of the dam requires institution of a regular maintainance program to correct such deficiencies prior to their leading to major problems. Alternatively, at the sacrifice of a useful recreational resource, the dam could be breached.

(b) O & M Procedures

Implementation of the following measures will assist the owners in assuring the long-term safety of the dam:

- (1) Clear all debris, particularly logs and branches, from the downstream channel.
- (2) Reconstruct the right downstream training wall.
- (3) Clean out and seal all cracks in the concrete portions of the dam, particularly the spillway, and repair all spalled areas.
- (4) Install a staff gage upstream of the dam which will provide visual readings during flood periods. These observations will provide information on future flood discharges.
- (5) Continual surveillance of the dam should be provided by the owner during periods of unusually heavy precipitation. The owner should also establish a formal system with local officials for warning downstream residents in case of emergency.

APPENDIX A
VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Dates: 1 June 1978
8 July 1978 - 11:00 a.m. (Measurements)
12 July 1978 - 11:00 a.m. (Hydrology)

NH 00288
TODD LAKE DAM
Bradford, New Hampshire
Ring Brook
NHWRB 28.01

Weather: Sunny, warm all days

INSPECTION TEAM

James H. Reynolds	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZDA)	Team Captain
William S. Zoino	GZDA	Soils
Nicholas A. Campagna	GZDA	Soils
Robert Minutoli	GZDA	Soils
Andrew Christo	Andrew Christo Engineers (ACE)	Structural & Mechanical
Paul Razgha	ACE	Structural & Mechanical
Guillermo J. Vicens	Resource Analysis, Inc. (RAI)	Hydrology
David H. Marks	RAI	Hydrology
Richard L. Laramie	RAI	Hydrology
Duncan W. Wood	RAI	Hydrology

Mr. Donald A. Garman, president of the Lake Todd Association was present during the 1 June 1978 inspection.

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
ROCK & EARTH EMBANKMENT		
Movement or Settlement of Crest	<i>NAC</i>	None noted
Vertical Alignment	<i>NAC</i>	No movement noted
Horizontal Alignment	<i>NAC</i>	No movement noted
Condition at Abutment and at Concrete Structures	<i>ic</i>	Right abutment: some movement of squared stone and medium random cracks and efflorescence on cap Left abutment: some spalling and random cracks of and efflorescence on concrete
Unusual Movement at or near Toes		
Unusual Downstream Seepage	<i>NAC</i>	None noted
Foundation Drainage Features	<i>a</i>	None visible
Toe Drains	<i>ric</i>	None visible
OUTLET WORKS		
(a) Approach Channel		
Slope Conditions	<i>NAC</i>	Shallow approach from pond
Bottom Conditions	<i>DL</i>	Not visible
Log Boom		None
Debris		None
Trees overhanging channel	<i>DL</i>	None

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
(b) Outlet Structure General Condition of Concrete Rust or Staining Spalling Erosion or Cavitation Visible Reinforcing Seepage or Efflorescence Cracking Wooden Penstock Stop-logs	AC	Good; inlets and outlets sealed but minor leakage through wood seals None noted None noted None noted None noted Some efflorescence on box structure Some medium random cracks Very poor, about 50 percent of wood deteriorated Not visible (submerged)
(c) Spillway Weir General Condition of Concrete Rust or Staining Spalling Visible Reinforcing Seepage or Efflorescence Cracking Condition of flashboards	AC	Good None Minor None None 24-foot long horizontal crack on downstream face of cap between flashboard sections Good

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
(d) Outlet Channel		
General Condition	<i>de</i>	Some brush, logs and other debris
Loose Rock Overhanging Channel	<i>de</i>	Right rock training wall collapsed into channel
Trees Overhanging Channel	<i>de</i>	None
Floor of Channel	<i>de</i>	Loose rock
Other Obstructions		Road bridge 100 ft. downstream
(e) Existence of gages		None
RESERVOIR		
Shoreline		Stable to 1500 feet upstream on either side
Sedimentation		None noted
Upstream hazards in the event of backflooding		50-60 beach front homes subject to inundation if lake rises 5 feet
Changes in the nature of watershed (agriculture, logging, construction, etc.)		None noted, watershed primarily forest
DOWNSTREAM CHANNEL		
Restraints on dam operation	<i>de</i>	Road bridge with arch opening 100 ft. downstream of dam might cause significant back-flooding. Downstream channel very narrow

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
OPERATION AND MAINTENANCE FEATURES		
Reservoir regulation plan		
Normal procedures	<i>re</i>	Flashboards inserted by Memorial Day and removed by end of September
Emergency procedures	<i>re</i>	Removal of 2-12 inch flashboards provides little emergency relief. No warning system in effect, but probably not required.

APPENDIX B

		<u>Page</u>
Figure 1	Site Plan	B-2
Figure 2	Plan of Dam and Old Mill	B-3
Figure 3	Elevation of Dam	B-4
	List of pertinent records not included and their location	B-5
	Letter from NED to the Lake Todd Association concerning the availability of federal funds to install a gate at the dam	B-6

TODD LAKE
1983 EL. 670±

N

OLD ROUTE 103

CONVERTED
MILL
BUILDING

OLD CONCRETE FOOTING

CONC. GUARDRAIL

OLD ROUTE 103

HOUSE

HOUSE

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

FIG. 1

SITE PLAN

TODD LAKE

NEW HAMPSHIRE

SCALE

DATE

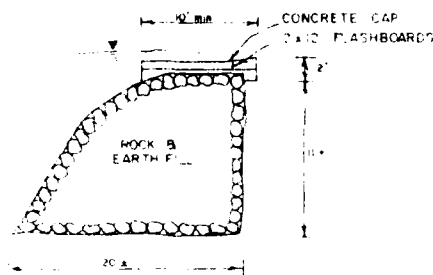
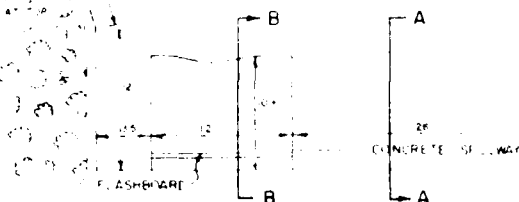
FILE No 2067

CONCRETE CAP ADDED IN 1946

NOTE: DIMENSIONS PART V
FROM 1936 NHDAD
REPORT

ROCK &
EARTH FILL

SECTION A-A
SCALE 1" = 10'



SECTION B-B
SCALE 1" = 10'

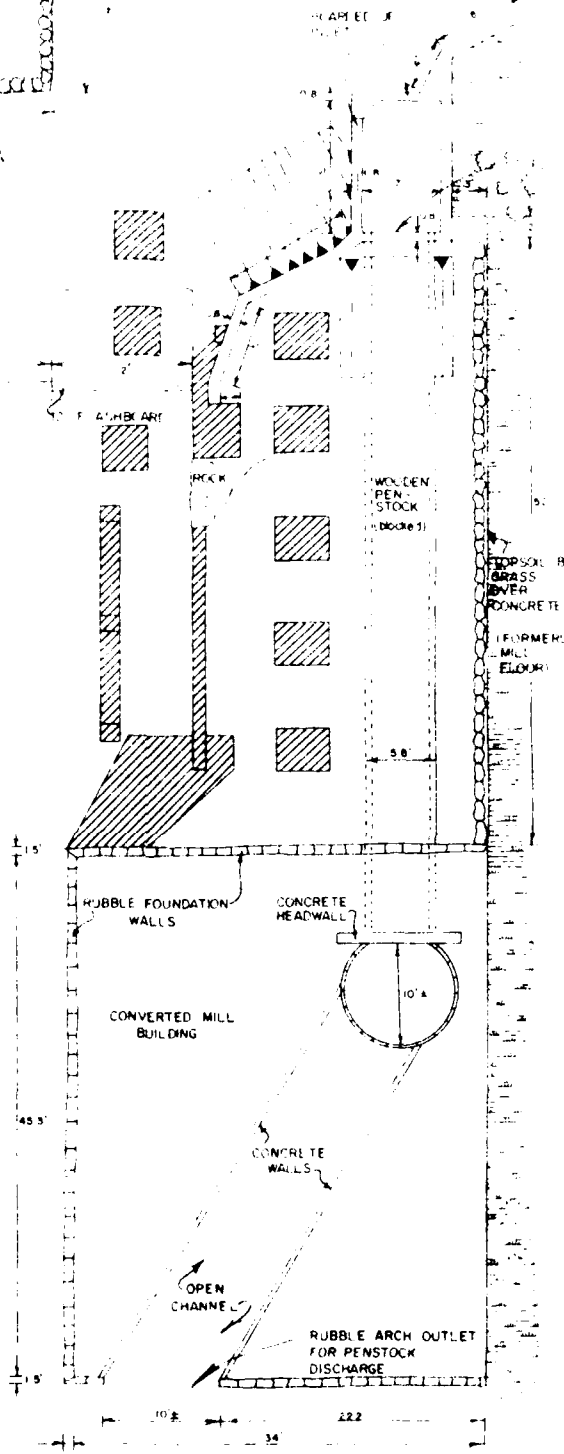
E No. 2067

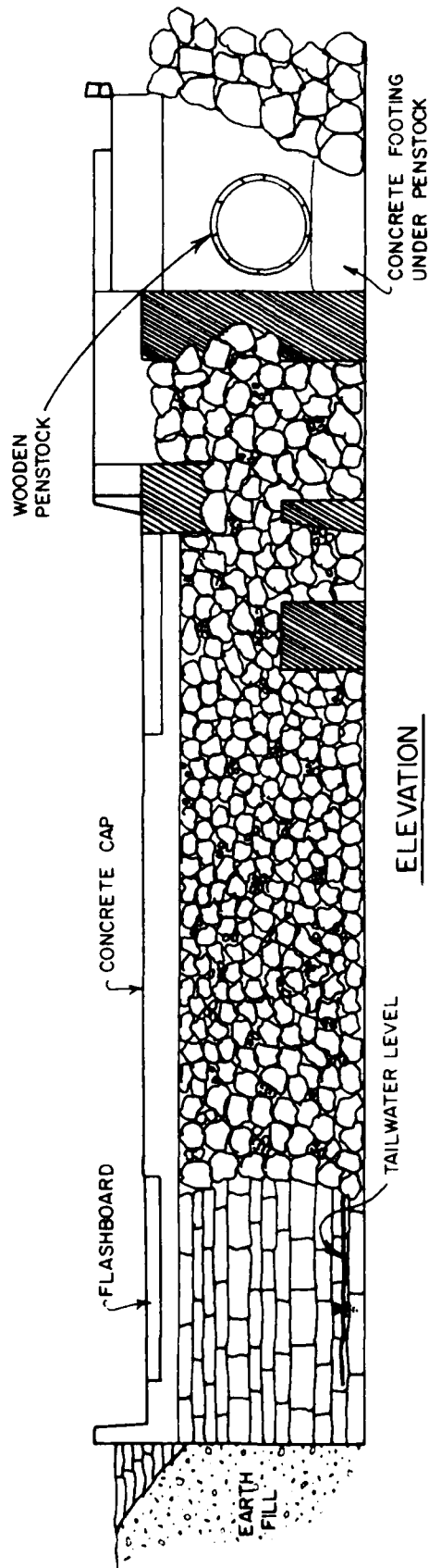
OLD CONCRETE MILL
FOOTINGS

ENGINEERING DIVISION, U.S. ARMY
CORPS OF ENGINEERS
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS
U.S. ARMY ENGINEER DISTRICT OFFICE
NEW ORLEANS, LOUISIANA

PLAN OF DAM AND OLD MILL

FIG. 2





GOLDEN, ZOMO, DUNNCLIFF & ASSOC., INC.
 GEOTECHNICAL CONSULTANTS
 NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV NEW ENGLAND
 CORPS OF ENGINEERS
 WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

FIG. 3

ELEVATION OF DAM

TODD LAKE

NEW HAMPSHIRE

SCALE 1" = 10'

DATE JULY 1978

FILE No 2067

The NHWRB maintains the majority of information regarding the Todd Lake Dam. Included in these records are:

- (a) Letter dated 8 June 1976 from Donald A. Gorman to the NHWRB concerning the findings of the Board's April 1976 inspection.
- (b) Site evaluation report by the NHWRB dated 28 April 1976.
- (c) Report of 28 April 1976 inspection by the NHWRB.
- (d) Letter dated 27 January 1976 from the NHWRB to the Lake Todd concerning repairs recommended after the May 1971 inspection by the NHWRB.
- (e) Site evaluation report by the NHWRB dated 19 August 1975.
- (f) Memorandum dated 13 August 1975 concerning flooding in the West Branch of the Warner River and prepared by the NHWRB.
- (g) Report of 17 May 1971 inspection by the NHWRB.
- (h) A 1951 analysis of the discharges from Todd Lake prepared by the NHWRB.
- (i) A 1944 request to the New Hampshire Water Control Commission (NHWCC) by Carl F. Milner to repair the dam at Todd Lake.
- (j) A NHWCC data card dated 5 September 1939.
- (k) A sketch of the dam dated 10 July 1939 by the NHWRB.
- (l) A 1939 NHWCC report entitled "Data on Reservoirs and Dams in New Hampshire."
- (m) A 1938 NHWCC report entitled "Data on Power Development in New Hampshire."
- (n) A 1938 NHWCC report entitled "Data on Dams in New Hampshire."
- (o) A 1934 NHWRB report entitled "Inventory of Dams and Water Power Developments."
- (p) An undated Public Service Commission of New Hampshire "Dam Record."

The Board has offices in the State Capital and can be reached at (603) 271-3406 or through (603) 271-1110.



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

RECEIVED
L.M.M.S.

REPLY TO
ATTENTION OF:

NEDPL-P

20 May 1977

Mr. Donald A. Garman, President
Lake Todd Association
Box 168
Bradford, N.H. 03221

Dear Mr. Garman:

This will inform you of our findings resulting from reconnaissance scope investigations of the Lake Todd Dam in Bradford, New Hampshire. In response to Congressman James C. Cleveland's letter of 4 January 1977, on your behalf, members of my staff met with you on 7 April 1977 to discuss and inspect the subject problem area. The purpose of the meeting was to determine if Federal funding could be utilized for installation of a sluice gate at the Lake Todd Dam.

Lake Todd is an artificially created lake, located in the towns of Bradford and Newbury, New Hampshire, about 25 miles west of Concord. The damming of a water course, which was part of the Warner River system within the Merrimack watershed, created Lake Todd more than 100 years ago. The water level in Lake Todd is maintained by underground springs and the runoff collected by small streams in the surrounding hills. Route 103, a former railroad crossing, divides the lake into two sections. Preservation and development around the immediate pond area is provided through the efforts of the Lake Todd Association. Years ago, a mill was located on the left abutment of the dam and, by means of a penstock, obtained water to operate the mill machinery. The mill has been closed down for a long time and was just recently bought and is being converted into a residence by the new owner. The old wooden penstock is in an advanced state of decay and its intake has been boarded up by the Lake Todd Association.

Presently, the primary use of the dam is to maintain a sufficiently high water level in Lake Todd for recreational use during the summer months. This regulation is achieved by the insertion of a flashboard along the crest of the dam near each abutment at the beginning of the summer.

NEDPL-P

20 May 1977

Mr. Donald A. Garman, President

In August 1975, the New Hampshire Water Resources Board, in accordance with state statutes, made an inspection of the Lake Todd Dam and found it deficient in several areas. The principal problems involved the penstock and its intake structure which the association had boarded up. The boarded up intake structure was leaking noticeably and could not be operated to regulate flow through the dam. The association was informed, in January 1976, that corrective action should be taken to remedy the problem so as to increase flow capacity during times of flooding in order to insure the stability of the dam.

In conversation with the New Hampshire Water Resources Board, we were informed that installation of a moveable sluice gate was not the only solution to correct the problem and thus bring the dam in line with state statutes. The use of an operational stoplog gate in place of the boarded up penstock intake, or the lowering of the crest of the dam in conjunction with the installation of a new flashboard structure on top of the dam and permanent closure of the penstock intake, would also be acceptable to the state.

For the most part, there is no flooding problem upstream of the Lake Todd Dam. Some limited flooding does occur to low-lying land adjacent to the shores of the lake, but it is of short duration and causes very minor economic damage. Under authority contained in Section 205 of the 1948 Flood Control Act, as amended, the Corps is able to participate in the construction of flood control projects if flood prevention benefits exceed project costs. Inasmuch as only minor economic losses are incurred during times of flooding, Federal participation to install a sluice gate at the Lake Todd Dam is not feasible or economically justified.

A copy of this letter is being forwarded to the New Hampshire Water Resources Board for their information.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

CF:
✓ Mr. George McGee, Sr., Chairman
N.H. Water Resources Board
37 Pleasant Street
Concord, N.H. 03301

APPENDIX C
SELECTED PHOTOGRAPHS

C-1

TODD LAKE
USGS EL. 670±

N

OLD ROUTE 103

CONVERTED
MILL
BUILDING

▶ OVERVIEW PHOTOS

▷ APPENDIX C PHOTOS

▨ OLD CONCRETE FOOTING

OLD ROUTE 103

HOUSE

HOUSE

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

LOCATION AND ORIENTATION OF PHOTOS

FILE No. 2067

TODD LAKE

NEW HAMPSHIRE

SCALE 1" = 20'

DATE JULY 1978

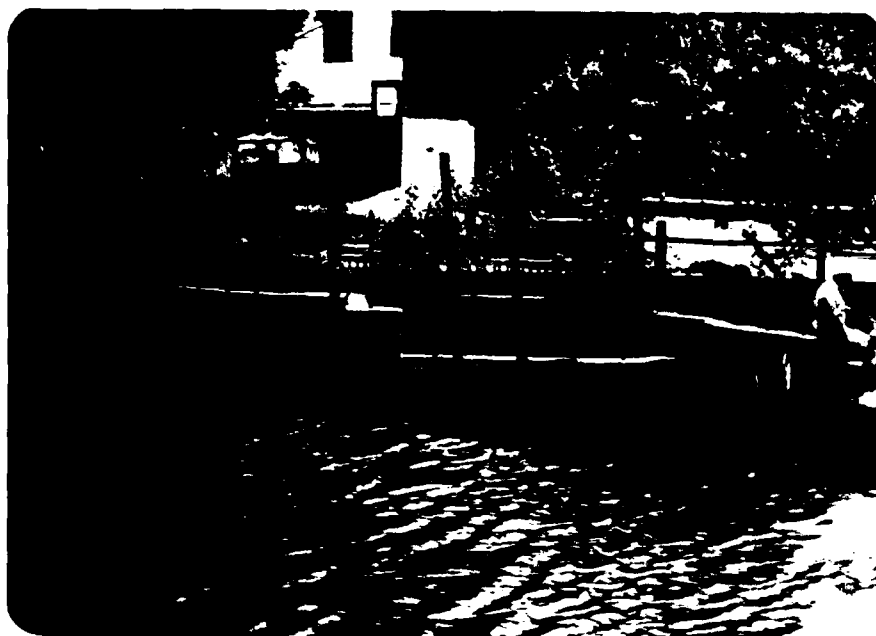
C-2



1. View of right abutment and right side of spillway from downstream (8 July 78)



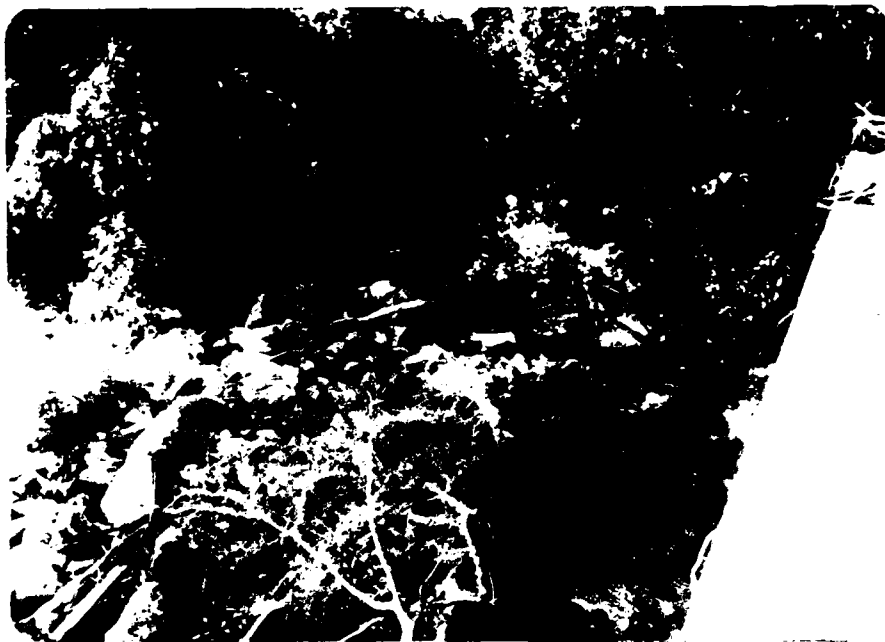
2. View of displaced rock and bulge at toe of dam beneath center of spillway from left abutment (8 July 78)



3. View of outlet structure from right abutment
(1 June 78)



4. Detail of spalling and efflorescence on
concrete forming left abutment (1 June 78)



5. View of collapsed right training wall
from left abutment (8 July 78)

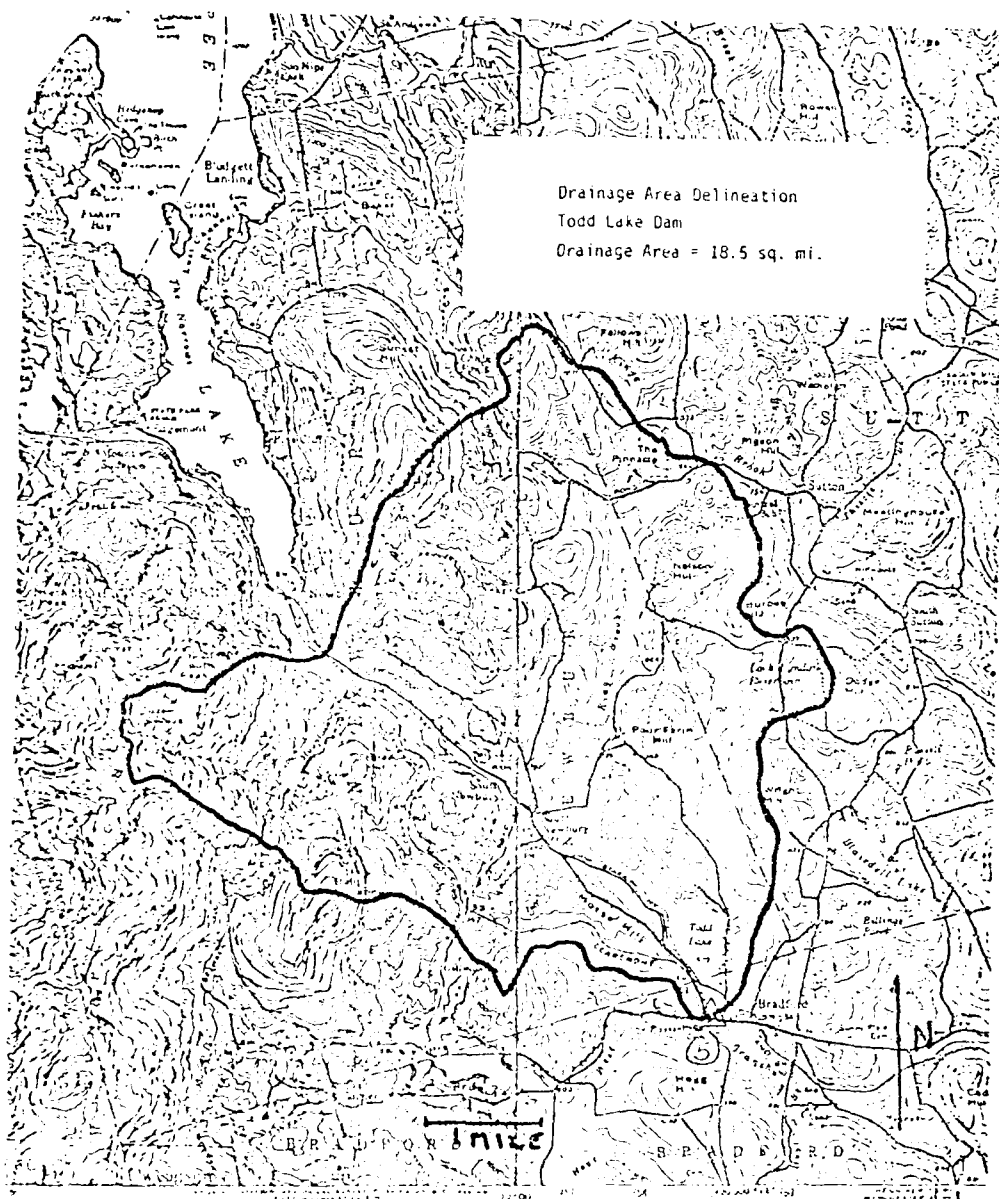


6. View of penstock from right abutment
(1 June 78)



7. View looking downstream of road bridge just below dam

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS
FOR
TODD LAKE DAM
NH 00288



Drainage Area Delineation
 Todd Lake Dam
 Drainage Area = 18.5 sq. mi.

Map scale: 1 inch = 1 mile
 Map projection: UTM
 Map datum: North American datum
 Map source: USGS
 Map date: 1977
 Map author: USGS
 Map title: Drainage Area Delineation
 Map notes: This map was prepared by the USGS for the purpose of delineating the drainage area of Todd Lake Dam. It is based on the 1977 North American datum and the USGS topographic maps of the area. The map shows the drainage area of Todd Lake Dam, which is 18.5 square miles. The map also shows the location of Todd Lake Dam and the surrounding area.

DAMS 148 TODD LAKE'S 7-13-79 DWU

SIZE CLASSIFICATION: INTERMEDIATE

HAZARD CLASSIFICATION: SIGNIFICANT

BASED ON EXISTENCE OF TWO RESIDENTIAL
STRUCTURES NEAR DAM, AND IMMEDIATE
DOWNSLOPE OF DAM, PLUS SIGNIFICANT RAINFALL

SPILLWAY DESIGN FLOOD: $\frac{1}{2}$ PMF \rightarrow PMF

DRAINAGE AREA 16.5 mi² (VAI)

OLD DATA (1937) 16.5 mi²

FROM COE CURVE -

GIVEN LOCH LYNCH RESERVATION AND
SUMMIT AREA ALONG WITH DRAINAGE AREA
A RUNOFF VALUE SIMILAR TO "TIDAL"
"ROLLING".

USE 1250 CSM, PMF = 18.5(1250) = 23125

$\frac{1}{2}$ PMF = 11563: FOR SDF USE 14000 cfs SINCE
TODD LAKE IS ON LOWER END OF SIGNIFICANT HAZARD CLASS.

THE RUNOFF INFLOW HYDROGRAPH WOULD BE
ATTENUATED BY STORAGE, USING THE COE METHOD

$$Q_{P2} = Q_{P1} \times \left(1 - \frac{S_{\text{stor}}}{19}\right) = 14000 \times \left(1 - \frac{2.11}{19}\right)$$

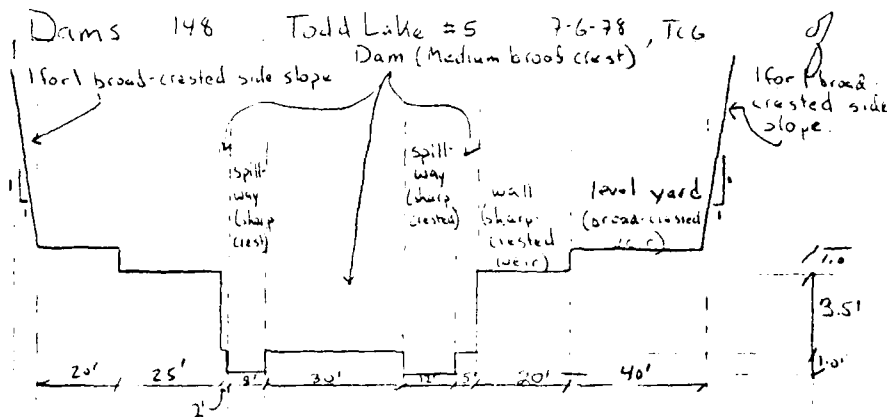
$$Q_{P1} \Rightarrow H_1 = 12.4 \Rightarrow S_{\text{stor}} = 2.11$$

$$Q_{P2} = 12445 \Rightarrow H_2 = 11.8 \Rightarrow S_{\text{stor}} = 2.01$$

$$S_{\text{stor}} = (2.11 + 2.01)/2 = 2.06$$

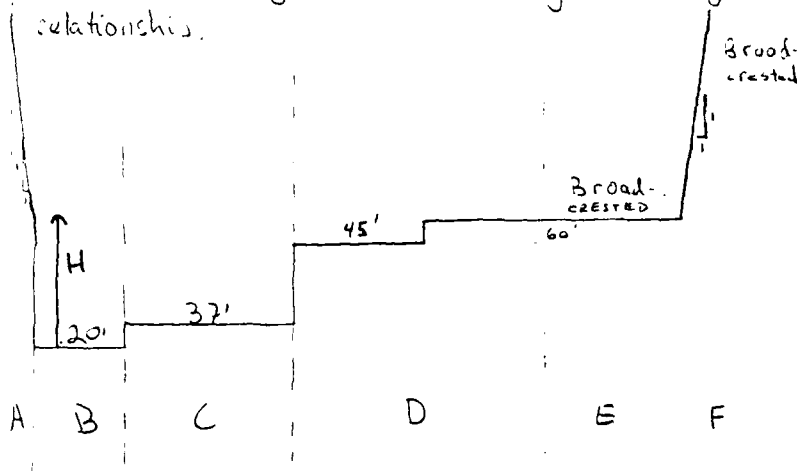
$$Q_{P3} = 14000 \left(1 - \frac{2.06}{19}\right) = 12482 \approx 12500 \text{ cfs}$$

$$H_3 \approx 11.8'$$



Elevation of Todd Lake Dam.

Since flow depends only on length and weir type, we could replace that dam with this "equivalent structure" and get the same stage-Discharge relationship.



Dams 148 Todd Lake #5 7-6-79, TL6

$$1. Q_A = C_A L_A H_A^{3/2}$$

$C_A = 2.8$ for broad-crested weir over ground

$$L_A = H - 5.5$$

$$H_A = .5(H - 5.5)$$

$$Q_A = 2.8 (H - 5.5) (.5(H - 5.5))^{3/2}$$

$$2. Q_B = C_B L_B H_B^{3/2}$$

$$C_B = 3.3$$

$$L_B = 20'$$

$$H_B = H$$

$$Q_B = 3.3 (20) H^{3/2}$$

$$3. Q_C = C_C L_C H_C^{3/2}$$

$$C_C = 3.0$$

$$L_C = 37'$$

$$H_C = H - 1.0$$

$$Q_C = 3.0 (37) (H - 1.0)^{3/2}$$

$$4. Q_D = C_D L_D H_D^{3/2}$$

$$C_D = 3.3$$

$$L_D = 45'$$

$$H_D = H - 4.5$$

$$Q_D = 3.3 (45) (H - 4.5)^{3/2}$$

Dams 148 Todd Lake #5 7-6-78, TCG

8/

$$5. Q_E = C_E L_E H_E$$

$$C_E = 3.0$$

$$L_E = 60'$$

$$H_E = H - 5.5$$

$$Q_E = 3.0 (60) (H - 5.5)^{3/2}$$

$$6. Q_F = Q_A = 2.8 (H - 5.5) (.5 (H - 5.5))^{3/2}$$

$$Q_{TOT} = Q_A + Q_B + Q_C + Q_D + Q_E + Q_F$$

```

LIST
100 REM STAGE DISCHARGE CALC FOR TODD LAKE DAM JOB 148
110 REM QA=Q3, QB=Q1, QC=Q2, QD=Q4, QE=Q5, QF=Q6, TOTAL=Q9
120 PAGE
130 C1=3
140 C2=2.8
150 C3=3.3
160 E=1.5
170 PRINT "TOTAL DISCHARGE FROM TODD LAKE AS FUNC OF HEAD"
180 PRINT USING 190:
190 IMAGE // 21"HEAD"30T"DISCHARGE"
200 PRINT USING 210:
210 IMAGE 10T"TOTAL QA QB QC QD QE QF"
220 FOR H=0 TO 20 STEP 0.5
230 Q1=C3*20*H*E
240 Q2=0
250 IF H<=1 THEN 270
260 Q2=C1*37*(H-1)*E
270 Q3=0
280 Q4=0
290 Q5=0
300 Q6=0
310 IF H<=4.5 THEN 370
320 Q4=C3*45*(H-4.5)*E
330 IF H<=5.5 THEN 370
340 Q5=C1*60*(H-5.5)*E
350 Q6=C2*(H-5.5)*(0.5*(H-5.5))*E
360 Q3=C2*(H-5.5)*(0.5*(H-5.5))*E
370 Q9=Q1+Q2+Q3+Q4+Q5+Q6
380 PRINT USING 390:H,Q9,Q3,Q1,Q2,Q4,Q5,Q6
390 IMAGE 1T,2D,10,9D,50,80,80,80,80
400 NEXT H
410 END

```

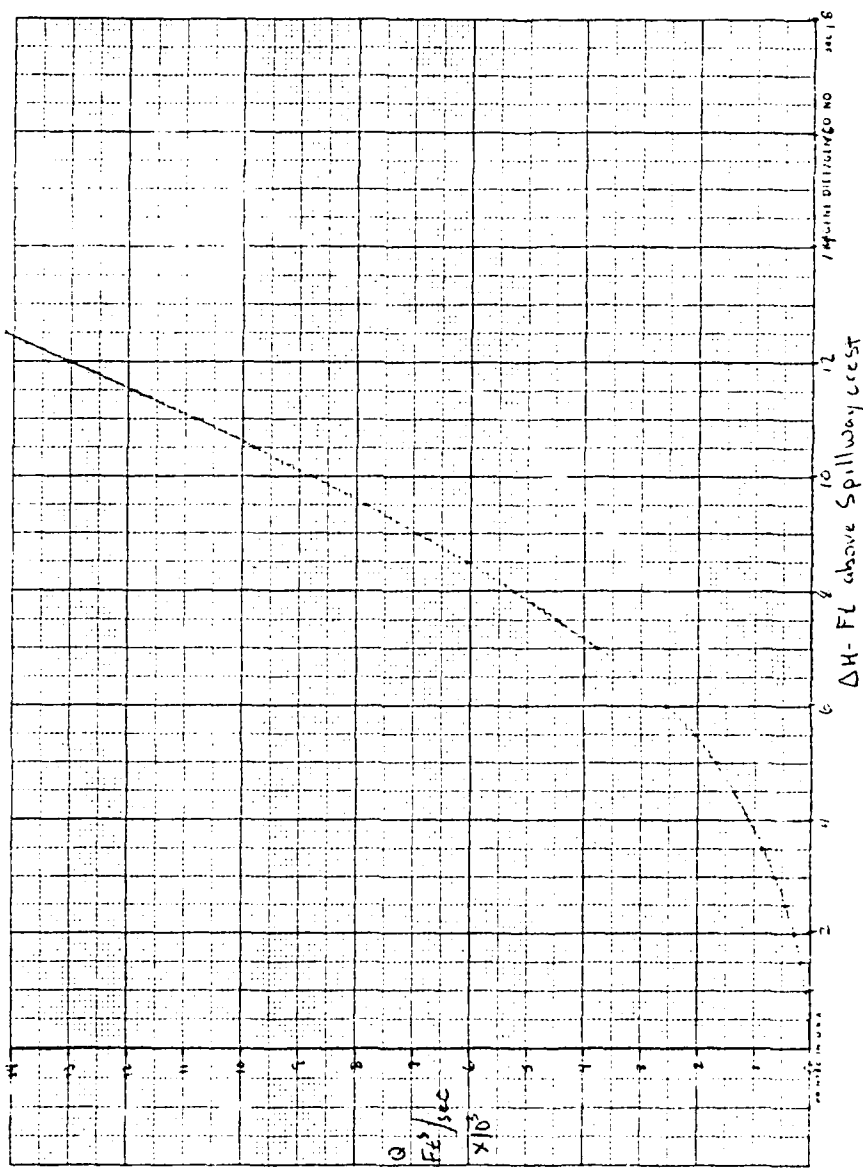
TOTAL DISCHARGE FROM TODD LAKE AS FUNC OF HEAD

HEAD	TOTAL	QA	QB	DISCHARGE	QC	QD	QE	QF
0.0	0	0	0	0	0	0	0	0
0.5	23	0	23	0	0	0	0	0
1.0	66	0	66	0	0	0	0	0
1.5	160	0	121	39	0	0	0	0
2.0	298	0	187	111	0	0	0	0
2.5	465	0	261	204	0	0	0	0
3.0	657	0	343	314	0	0	0	0
3.5	871	0	432	439	0	0	0	0
4.0	1105	0	528	577	0	0	0	0
4.5	1357	0	630	727	0	0	0	0
5.0	1678	0	738	888	0	0	0	0
5.5	2059	0	851	1060	53	149	64	0
6.0	2548	0	970	1241	273	273	180	0
6.5	3127	1	1094	1432	420	420	331	1
7.0	3777	3	1222	1631	587	587	509	3
7.5	4487	6	1356	1839	772	772	712	6
8.0	5253	10	1493	2056	972	972	935	10
8.5	6070	15	1636	2280	1188	1188	1179	15
9.0	6935	23	1782	2512	1418	1418	1440	23
9.5	7847	33	1933	2751	1660	1660	1718	33
10.0	8803	43	2087	2997	1915	1915	2012	43
10.5	9801	55	2246	3250	2182	2182	2322	55
11.0	10841	70	2409	3510	2461	2461	2645	70
11.5	11921	87	2574	3777	2750	2750	2983	87
12.0	13039	107	2744	4050	3050	3050	3334	107
12.5	14196	128	2917	4329	3360	3360	3697	128
13.0	15390	152	3094	4614	3680	3680	4073	152
13.5	16620	179	3274	4906	4009	4009	4461	179
14.0	17886	209	3457	5203	4348	4348	4860	209
14.5	19187	241	3644	5506	4696	4696		241

15.0	2527	375	3834	5815	5953	5271	275
15.0	2595	313	4028	6129	5418	3692	313
16.0	2732	354	4224	6449	5751	6124	354
16.0	2772	397	4424	6774	6133	6567	397
17.0	2901	444	4636	7104	6553	7020	444
17.0	2982	494	4852	7440	6961	7482	494
18.0	3235	547	5050	7780	7369	7955	547
18.0	3300	603	5252	8126	7779	8437	603
19.0	3396	663	5466	8477	8199	8928	663
19.0	3474	725	5683	8832	8667	9429	725
20.0	3682	793	5903	9193	9062	9939	793

TODD LAUER

DISCHARGE - STAGE CURVE



Dams 149 Told Lake #5 TCG 7-7-78

STORAGE - STAGE RELATIONSHIP

Surface area of lake from existing data is 168 acres

ASSUME NO SPREADING AS THE WATER RISES;

$$\begin{aligned} \text{For each foot of rise, } \Delta \text{ storage} &= \Delta S = 168 \text{ acre ft} \cdot (4)(A) \\ &= 168(43,560) = 7,318,080 \text{ ft}^3 \end{aligned}$$

WITH A DRAINAGE AREA OF 18.5 mi²

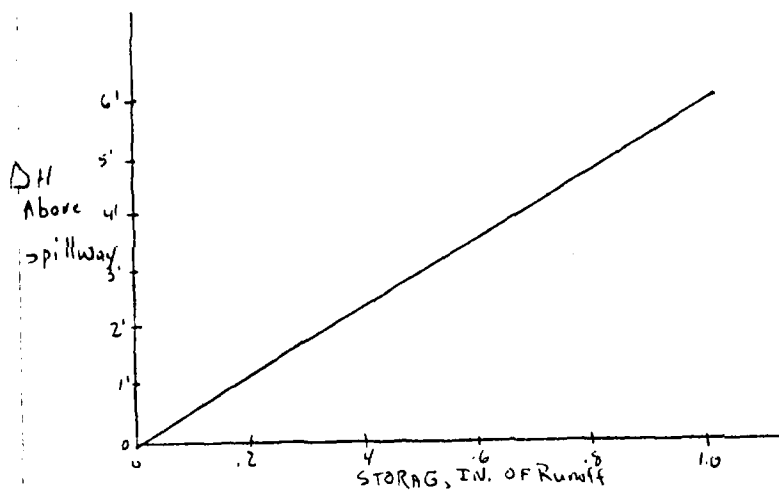
1" of runoff would cause:

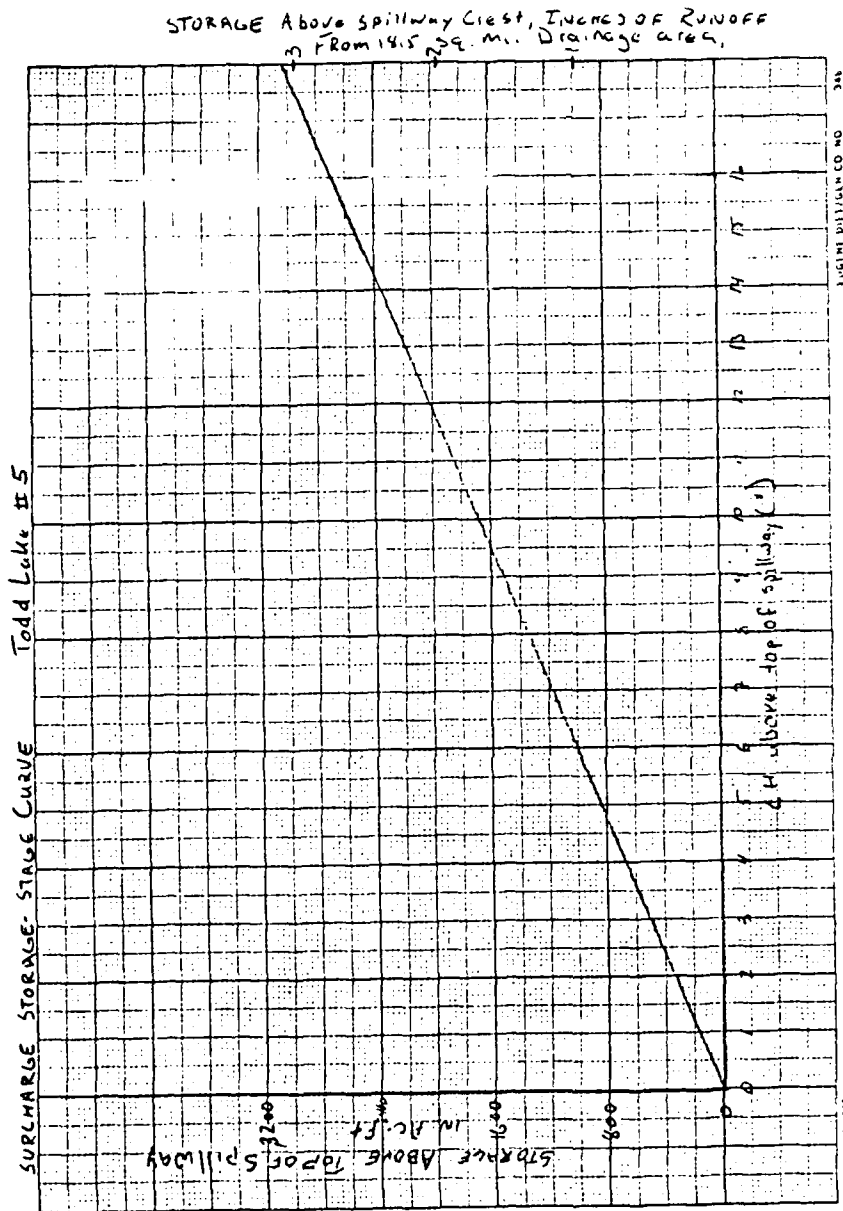
$$\frac{18.5 \text{ (mi}^2\text{)}}{168 \text{ acre } (.0015625 \frac{\text{mi}^2}{\text{acre}})} = 70.48" \text{ rise in water surface}$$

1 foot of rise = .170" runoff

2 feet " " = .341" "

3 " " " = .511" " , etc.

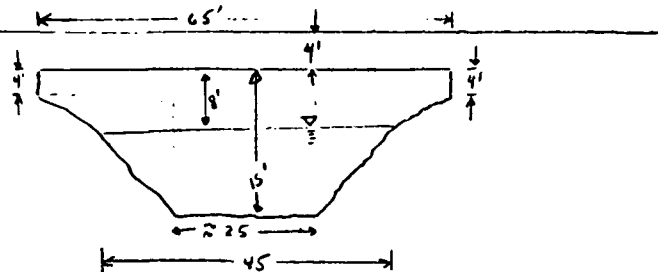




DAMS 148 TODD LAKE 7-13-78 DWW

SOME CONSIDERATION MUST BE GIVEN TO WHETHER OR NOT THE NEW RITE 103 HIGHWAY EMBANKMENT WHICH FOLLOWS THE ALIGNMENT OF THE OLD RAILROAD WILL SERVE AS A DAM AND THIS REDUCE THE PEAK FLOW THAT REACHES THE TODD LAKE DAM. A CROSS SECTION AT THE HIGHWAY BRIDGE WAS TAKEN ON 7/12/78.

NOT TO SCALE



GIVEN THE LARGE OPENING $\approx 750 \text{ FT}^2$ AND THE LIMITED FREEBOARD OVER THE BRIDGE GOING TO PRESSURE FLOW, IT IS UNLIKELY THAT A SIGNIFICANT REDUCTION IN FLOW WOULD RESULT FROM THE BRIDGE.

A SECOND CONCERN IS WHETHER THE STORAGE IN THE LAKE FOR A 11.8' SURCHARGE EXCEEDS THE TOTAL PROBABLE MAXIMUM RUNOFF.

DAMS 148

TODD LAKE #5

7-13-78

ZWW

19" Prob. MAX. RUNOFF From 18.5 mi²

MCODS

$$\frac{19}{12} \times 18.5 \times 5280^2 = 18747 \text{ AF}$$

43560

STORAGE AT H = 11.8 FT IS \approx 2000 AF

THUS THE RISE WATER SURFACE IS
FEASIBLE.

Todd Lake

TCG 7-8-78

P. 8

ESTIMATED DOWNSTREAM DAM FAILURE FLOOD STAGES

Based on LOE "Rule of Thumb" Guidance, April, 1978

STEP 1: RESERVOIR STORAGE AT TIME OF FAILURE

ASSUME: FAILURE WHEN STAGE IS 3.5 foot over
side weirs, 8.0 ft, over normal spillway elevation, 7.0
ft over the top of the dam. THIS IS \approx A 100 YEAR FLOOD LEVEL
WHERE $Q \approx 5000$ cfs
 $S = \text{Normal storage} + \text{surcharge}$.

Normal storage at the top of the dam
(1' above spillway crest) is 1513 ac-ft.
surcharge is 1200 ac-ft.

$$S = 1513 + 1200 = 2713 \text{ AC-Ft}$$

STEP 2: PEAK FAILURE OUTFLOW (Q_{P1})

$$Q_{P1} = \frac{8}{27} W_b \sqrt{g} Y_o^{3/2}$$

$$W_b = 40\% \text{ of width} = .4(102) \approx 40.8'$$

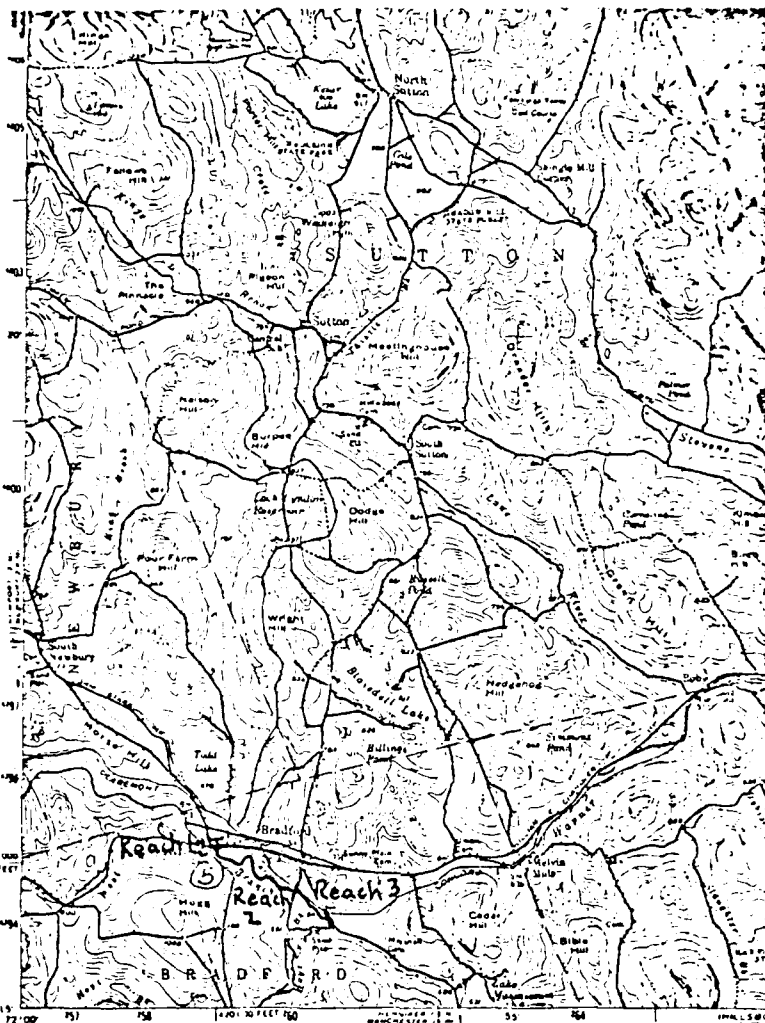
$$g = 32.2$$

$$Y_o = 12.0' + 7' = 19.0'$$

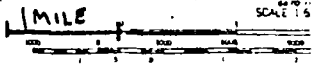
$$Q_{P1} = \frac{8}{27} (40.8) \sqrt{32.2} 19^{3/2} \\ = 5680 \text{ cfs}$$

19
5

NOVELL, WING
1950



Mapped, edited and published by the Geological Survey
 General by USGS and USCGS
 Topography by planimeter surveys 1926. Revised 1956
 Potentiometric projection. 1927 Mean American datum
 10 000-foot grid based on New Hampshire coordinate system
 1000-foot Universal Transverse Mercator grid ticks
 zone 19 shown in blue
 Area along Blackwater River covered by double light blue
 pattern is subject to seasonal inundation to 500 feet



CONTOUR INTERVAL
 20 feet

FOR SALE BY U.S. GEOLOGICAL SURVEY
 A FOLDER DESCRIBING TOPOGRAPHIC MAPS AT

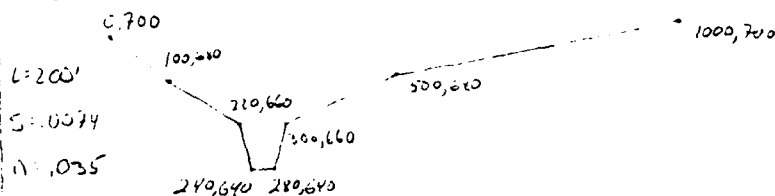
Tokil Lake

TCC 7-8-79

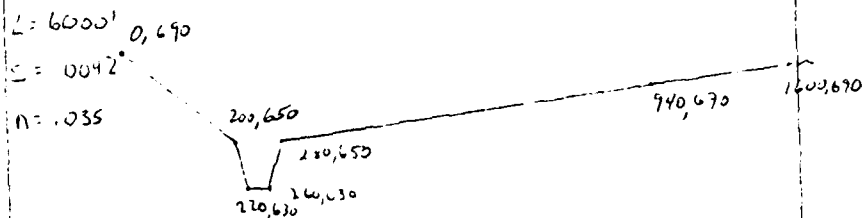
Pf

Step 3. Assumed X-Sections for reaches shown on the U.S.G.S. Topo Map:

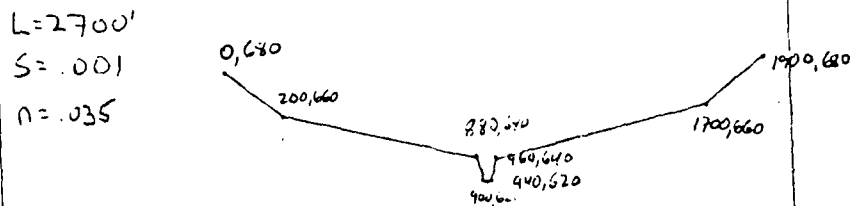
Reach 1 - Below dam to 103 Bridge



Reach 2 - 103 Bridge 114 Bridge



Reach 3 114 Bridge to 114 Bridge #2



DEPTH	ELEV	AREA	WPER	HYD-R	AR2X	Q
0.0	640.0	0.0	0.0	0.0	0.0	0.0
1.0	641.0	41.0	42.8	1.0	39.8	145.8
2.0	642.0	84.0	45.7	1.0	126.1	462.0
3.0	643.0	129.0	48.5	2.7	247.8	987.4
4.0	644.0	175.0	51.3	3.4	400.4	1466.5
5.0	645.0	225.0	54.1	4.2	581.9	2130.9
6.0	646.0	276.0	57.0	4.0	798.6	2895.4
7.0	647.0	329.0	59.8	5.5	1025.9	3757.0
8.0	648.0	384.0	62.5	6.1	1287.2	4713.8
9.0	649.0	441.0	65.3	6.7	1574.1	5764.7
10.0	650.0	500.0	68.3	7.3	1886.6	6909.2
11.0	651.0	551.0	71.1	7.9	2224.7	8147.2
12.0	652.0	622.0	73.9	8.4	2588.4	9478.9
13.0	653.0	689.0	76.8	9.0	2977.8	10905.8
14.0	654.0	756.0	79.6	9.5	3393.1	12425.9
15.0	655.0	825.0	82.4	10.0	3834.5	14042.6
16.0	656.0	896.0	85.3	10.5	4302.4	15753.9
17.0	657.0	969.0	88.1	11.0	4796.9	17566.8
18.0	658.0	1044.0	90.9	11.5	5318.3	19476.4
19.0	659.0	1121.0	93.7	12.0	5867.0	21485.8
20.0	660.0	1200.0	96.5	12.4	6443.3	23596.3
21.0	661.0	1288.0	112.7	12.4	6540.2	23951.2
22.0	662.0	1392.0	128.8	10.0	6886.6	24933.9
23.0	663.0	1512.0	145.0	10.4	7223.5	26453.4
24.0	664.0	1648.0	161.1	10.2	7772.1	28462.3
25.0	665.0	1800.0	177.2	10.2	8448.2	30938.3
26.0	666.0	1968.0	193.4	10.2	9249.7	33873.6
27.0	667.0	2152.0	209.5	10.3	10177.1	37269.8
28.0	668.0	2352.0	225.6	10.4	11232.4	41134.4
29.0	669.0	2568.0	241.8	10.6	12418.7	45478.8

TODD LAKE DAM - REACH 1

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	630.0	0.0	0.0	0.0	0.0	0.0
1.0	631.0	41.0	42.0	1.0	39.0	109.9
2.0	632.0	84.0	45.7	1.8	126.1	380.6
3.0	633.0	129.0	48.5	2.3	247.8	683.6
4.0	634.0	176.0	51.3	3.4	400.4	1104.8
5.0	635.0	225.0	54.1	4.2	581.9	1605.3
6.0	636.0	276.0	57.0	4.8	790.6	2181.7
7.0	637.0	329.0	59.8	5.5	1025.9	2830.4
8.0	638.0	384.0	62.6	6.1	1287.2	3551.2
9.0	639.0	441.0	65.5	6.7	1574.1	4342.9
10.0	640.0	500.0	68.3	7.3	1886.6	5255.2
11.0	641.0	561.0	71.1	7.9	2224.7	6177.8
12.0	642.0	624.0	73.9	8.4	2588.4	7141.2
13.0	643.0	689.0	76.8	9.0	2977.8	8215.5
14.0	644.0	756.0	79.6	9.5	3393.1	9361.3
15.0	645.0	825.0	82.4	10.0	3834.3	10575.3
16.0	646.0	896.0	85.3	10.5	4302.4	11870.0
17.0	647.0	969.0	88.1	11.0	4796.9	13234.3
18.0	648.0	1044.0	90.9	11.5	5318.3	14672.9
19.0	649.0	1121.0	93.7	12.0	5867.0	16186.8
20.0	650.0	1200.0	96.6	12.4	6443.3	17776.8
21.0	651.0	1299.0	99.4	12.8	7049.8	19458.9
22.0	652.0	1436.0	102.2	13.2	7695.8	21256.1
23.0	653.0	1611.0	104.9	13.6	8383.9	23192.3
24.0	654.0	1824.0	107.7	14.0	9111.1	25308.3
25.0	655.0	2075.0	110.5	14.4	9876.1	27611.1
26.0	656.0	2364.0	113.3	14.8	10683.9	30112.3
27.0	657.0	2691.0	116.1	15.2	11530.9	32826.6
28.0	658.0	3056.0	118.9	15.6	12448.4	35779.5
29.0	659.0	3459.0	121.6	16.0	13433.3	38947.4

TODD LAKE DAM - REACH 2

DEPTH	ELEV	AREA	UPER	HYD-R	AR2/3	0
0.0	620.0	0.0	0.0	0.0	0.0	0.0
1.0	621.0	41.0	42.0	1.0	39.0	53.6
2.0	622.0	84.0	45.7	1.0	126.1	169.8
3.0	623.0	129.0	48.5	2.7	247.8	333.6
4.0	624.0	176.0	51.3	3.4	400.4	539.1
5.0	625.0	225.0	54.1	4.2	581.9	787.3
6.0	626.0	276.0	57.0	4.8	798.6	1064.4
7.0	627.0	329.0	59.8	5.5	1025.9	1381.1
8.0	628.0	384.0	62.6	6.1	1287.2	1732.8
9.0	629.0	441.0	65.5	6.7	1574.1	2119.1
10.0	630.0	500.0	68.3	7.3	1886.6	2538.9
11.0	631.0	561.0	71.1	7.9	2224.7	2995.0
12.0	632.0	624.0	73.9	8.4	2588.4	3484.5
13.0	633.0	689.0	75.8	9.0	2977.8	4008.7
14.0	634.0	756.0	75.6	9.5	3393.1	4567.9
15.0	635.0	825.0	82.4	10.0	3834.5	5162.2
16.0	636.0	896.0	85.3	10.5	4302.4	5792.0
17.0	637.0	969.0	88.1	11.0	4796.9	6457.7
18.0	638.0	1044.0	90.9	11.5	5318.3	7155.7
19.0	639.0	1121.0	93.7	12.0	5867.0	7898.4
20.0	640.0	1200.0	96.6	12.4	6443.7	8674.2
21.0	641.0	1315.5	101.6	12.8	7059.2	9495.3
22.0	642.0	1502.0	109.7	13.6	7723.6	10369.5
23.0	643.0	1759.5	130.7	15.2	8466.0	11306.9
24.0	644.0	2088.0	151.7	16.3	9297.6	12317.3
25.0	645.0	2487.0	177.7	17.5	10161.5	13408.7
26.0	646.0	2958.0	203.7	18.5	11098.5	14582.5
27.0	647.0	3499.5	233.8	19.3	12125.0	15880.7
28.0	648.0	4112.0	264.8	20.2	13264.2	17364.3
29.0	649.0	4795.5	295.8	21.5	14542.2	18959.8

TODD LAKE DAM - REACH 3

DAMS 148

TODD LAKE

7-14-78

DWW

STEP 4: REACH 1:

$$Q_{P1} = 5680 \text{ cfs}$$

$$H = 8.9 \text{ FT} \quad \text{AREA} = 430 \text{ FT}^2$$

$$V_1 = L \times \text{AREA} = 200' \times 430' = 86000 \text{ FT}^3 / 43560 = 1.97 \text{ AF}$$

OBSVIOUSLY THERE WOULD BE NO ATTENUATION
WHEN COMPARED TO $S = 2713 \text{ AF}$

REACH 2:

$$Q_{P1} = 5680 \text{ cfs}$$

$$H = 10.5 \quad \text{AREA} = 530 \text{ FT}^2$$

$$V_1 = L \times \text{AREA} = 6000' \times 530' = 3.18 \times 10^6 \text{ FT}^3$$

$$\frac{3.18 \times 10^6}{43560} = 73.0 \text{ AF} \approx \frac{1}{2} S$$

$$Q_{P21} = Q_{P1} \left(1 - \frac{V_1}{S}\right) = 5680 \left(1 - \frac{73.0}{2713}\right) = 5527$$

$$H = 10.3 \quad \text{AREA} = 515'$$

$$V_1 = 6000 \times 515 = 3.09 \times 10^6 \text{ FT}^3 \quad \frac{3.09 \times 10^6}{43560} = 70.9 \text{ AF}$$

$$V_{AW} = 72'$$

$$Q_{P2} = Q_{P1} \left(1 - \frac{V_{AW}}{S}\right) = 5680 \left(1 - \frac{72}{2713}\right) = 5529.$$

REACH 3: $Q_{P1} = 5529.$

$$H = 15.6 \quad \text{AREA} = 868 \text{ FT}^2$$

$$V_1 = L \times \text{AREA} = 2700' \times 868' = 2.34 \times 10^6 \quad \frac{2.34 \times 10^6}{43560} = 53.8 \text{ AF}$$

$$Q_{P21} = Q_{P1} \left(1 - \frac{V_1}{S}\right) = 5529 \left(1 - \frac{53.8}{2713}\right) = 5419$$

$$H = 15.5 \quad \text{AREA} = 860$$

$$V_1 = 2700 \times 860 / 43560 = 53.3 \text{ AF}$$

$$V_{AW} = 53.5$$

$$Q_{P3} = 5529 \left(1 - \frac{53.5}{2713}\right) = 5420.$$

$$H \approx 15.5'$$

DAMS 148

TODD LAKE

7-14-78 DW4

DISCUSSION ON DAM BREAK - DOWNSTREAM
FLOOD HAZARDS.

WITH THE EXCEPTION OF THE THREE BUILDINGS
IMMEDIATELY DOWNSTREAM OF TODD LAKE DAM THERE
IS NO SIGNIFICANT MAN MADE DEVELOPMENT IN
THE FLOOD PLAIN DOWNSTREAM OF THE DAM FILL
AT LEAST 3 MILES

THE FLOOD HAZARD FOR THE ASSUMED DAM
BREAK CONDITION WOULD BE LESS THAN THE
HAZARD RESULTING FROM THE LARGE E SDF.

THE WOODEN COVERED BRIDGE AT THE SECOND
ROAD CROSSING WOULD PROBABLY BE SEVERELY
DAMAGED IF THE DAM BROKE.

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS



INVENTORY OF DAMS IN THE UNITED STATES

STATE	DIVISION	STATE	COUNTY	DIST.	CONGR. DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE
NH	288	NH	013	02		TUDD LAKE DAM	4316.2	7150.0	08SEP78

POPULAR NAME	NAME OF IMPOUNDMENT
MILNER MILL DAM	TUDD LAKE

REGION BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01 05	HING BROOK	BRADFORD	0	679

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STATUS	HYDRAULIC HEIGHT	IMPOUNDING CAPACITIES	DIST UMN	FED N	PRV/FED	SCS A	VER/DATE
RAERPG	1854	R	14	13	1510	1100	N	N	N	17AUG78

REMARKS

D/S HAS	SPILLWAY	MAXIMUM DISCHARGE (CFS)	VOLUME OF DAM (CY)	POWER CAPACITY (KW)	INSTALLED PROPOSED	NAVIGATION LOCKS
P	90 C 33	1350	600			

OWNER	ENGINEERING BY	CONSTRUCTION BY
LAKE TUDD ASSOC		

DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BD	NH WATER RES BD	NH WATER RES BD	NH WATER RES BD

INSPECTION BY	INSPECTION DATE	AUTHORITY FOR INSPECTION
GOLDBERG ZUINO DUNNICLIFF + ASSOC	17JUN78	PL 92-367

REMARKS

END

FILMED

8-85

DTIC